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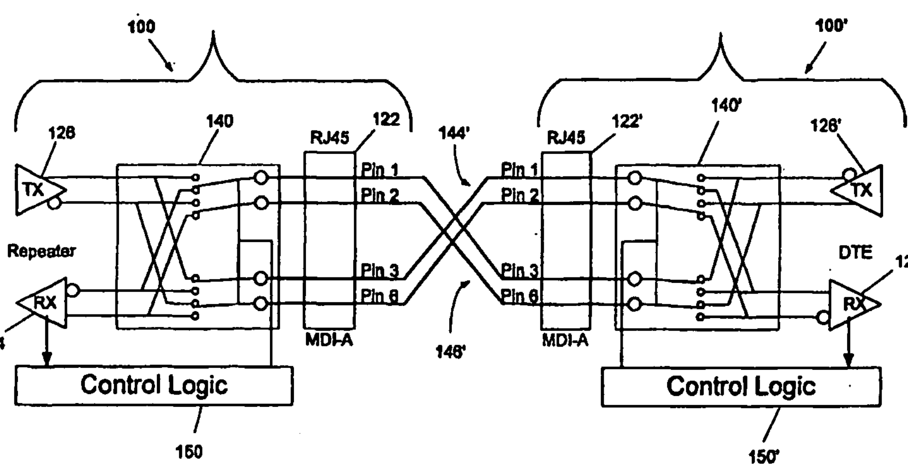

(57) Abstract

An automatic cross–over system (figure 3C) for a media dependent interface (MDI, 122 and 122') in a network device (100) includes a cross–over switch (140) interconnected between the media connector (MDI, 122 and 122') and the receiver (RX, 124) and transmitter (TX, 126). The cross–over switch (140) is configured to include at least two positions wherein: the first position connects a first signal path (144') to the receiver (RX, 124') and the second signal path (146') to the transmitter (TX 126'). The receiver (RX) is adapted for establishing a network connection over either signal path and for generating link established signals indicating whether a good link or network connect is established (128, figure 3A). The receiver (RX, 124) is adapted for determining whether a connection or link is established by determining whether a valid signal is present at the beginning and end of a timer cycle. The control logic (150) which receives the link established signal (128, figure 3A) and generates a switch control signal (142, figure 3A) for controlling the position of the cross–over switch (140).

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AUTOMATIC CROSSOVER SYSTEM FOR A MEDIA DEPENDENT INTERFACE WITH HYSTERESIS

BACKGROUND OF THE INVENTION

This invention relates to local area network (LAN) media interfaces and, more particularly, to a system which provides an automatic crossover function to insure that the LAN media interface wiring is properly connected.

A typical LAN connection consists of several point-to-point twisted pair links connecting two network devices, such as a Data Terminal Equipment (DTE) and a hub (i.e. a repeater or switch). A typical link will consist of two pairs, each pair connecting a transmitter on one end to a receiver at the other end and vice versa.

In most cases, the connectors at each end of the cable are identical, for example an RJ45 connector as used in Ethernet type LANs. Also, for practical reasons (simplicity and the ability to concatenate an arbitrary number of cables) a straight through cable is preferred. In a straight through cable the wiring between the two end connectors is point-to-point, i.e., pin 1 is connected to pin 1, pin 2 to pin 2 and so on.

To allow use of straight cables, the connectors at the hub and at a media access unit (MAU) or network interface adapter of the DTE interface cannot be wired the same way. If they were, then a transmitter would be connected to a transmitter and a receiver to a receiver, preventing communication between the devices. One of the end devices must perform a crossover function, i.e, connecting the transmitter at the same pins where the receiver is connected at the other end and connecting the receiver to the same pins where the transmitter is connected at the other end. For example the Ethernet standard recommends that the hub end be crossed over. The DTE interface is referred to as MDI (Media Dependent Interface) and the hub interface is referred to as MDI-X (Media Dependent Interface - Crossed/Over). FIG. 1 depicts the wiring as required by the Ethernet standard.

If all links were between repeaters or switches and DTEs, the crossover function at the repeater or switch would have allowed the use of straight cables everywhere. However, DTE's can be connected to other DTEs, repeaters to other repeaters or switches and devices called media converters (converting for example twisted pair copper media to fiber

optic media) may be connected to DTEs, repeaters or switches. When devices with the same type of interface (MDI or MDI-X) are connected together, a crossover cable must be used, for example, as shown in FIG. 2.

The use of crossover cables is not popular due to the following reasons: 1) there is no simple way to tell by inspection whether a cable is straight or crossed (it must be tested or marked in a different way); 2) use of two types of cables can lead to errors causing confusion and customer dissatisfaction; and 3) if a link consists of several concatenated cables, which is typical, then in order to achieve an end-to-end crossover the number of crossover cables must be odd. Information regarding the number of cables in the end to end connection is not always readily available and flexibility is compromised. These reasons also help explain why it is not practical to standardize on crossed over cables only.

DTE to DTE connections are rare but hub to hub (where a hub is either a repeater or a switch) are quite common. In a typical situation one hub port needs to be connected to another hub. In many cases, a network interfacing device, such as a hub, network interface adapter or a media converter, will have only one type of port. For example, hubs typically have MDI-X type ports, network interface adapters have MDI type ports and media converters have MDI type ports (because a media converter is more likely to be connected to a hub). In order to connect two devices that have ports of the same type, a crossover cable must be used.

Because of the strong preference of using straight cables only, vendors have provided two solutions that allow a port to be changed from MDI to MDI-X, as required. Typically, the network device has a small number of ports that are provided with the ability to be changed. In the first solution, the port utilizes two connectors, one is MDI and the other MDI-X. The user connects to one connector or the other connector (but not both) depending on what device resides at the other end. In the second solution, the port incorporates a manual switch (typically mechanical) that allows it to be either MDI or MDI-X, as required.

The crossover problem has become significant in the case of media conversion devices because they can be connected to both hubs and DTEs. Typically, media converters have been provided with a MDI interface because of the higher probability of being connected to a hub. More recently however, media conversion at the DTE is gaining

popularity and several vendors have introduced media converters with a manually switchable MDI to MDI-X interface.

Accordingly, it is an object of this invention to provide an improved network interfacing device.

It is another object of the invention to provide an improved network interfacing device which automatically conFIGS.itself for the appropriate interface.

It is yet another object of the invention to provide an improved network interfacing device which automatically selects the appropriate interface as necessary to establish a network connection.

It is a further object of the invention to provide an improved network interfacing device which includes an automatic crossover system to automatically select a MDI or MDI-X interface as necessary to establish a network connection.

It is a still further object of the invention to provide an improved method of automatically selecting the appropriate network interface in a network interfacing device.

It is yet a further object of the invention to provide an improved method of automatically selecting the appropriate network interface in a network interfacing device which allows two devices that have automatic network interface functionality to arrive at a compatible interface within a reasonable period of time.

It is yet another object of the present invention to provide an improved network interfering device which automatically selects the appropriate interface and which does not change state during negotiation between the devices being interfaced.

SUMMARY OF THE INVENTION

The invention is directed to an automatic cross-over system for a network interfacing device and a method for automatically configuring the network interface of the network interfacing device in order to establish a network connection. In order to establish a network connection between two network devices, a network medium, such as coaxial cable or twisted pair wiring, is connected between the network interfaces of both network devices. Where the network medium is a multiple conductor cable (such as twisted pair wiring) a straight through cable is preferred. However, the straight through cable requires that the network interfaces of each of the connected network devices be conFIG.d

differently, otherwise the transmitter of one network device would be connected to the transmitter (instead of the receiver) of the other network device.

In accordance with the present invention, an automatic cross-over system for a network interfacing device is disclosed. The network interfacing device includes a connector defining a plurality of signal paths which is adapted for connecting the network medium to the network interfacing device. The network interfacing device also includes a receiver for receiving signals from a remote network device via a first signal path and a transmitter for transmitting signals to the remote network device via a second signal path. In a first group of embodiments, the receiver is adapted for determining whether a connection or link is established with the remote system and for generating positive link established signals when a good link is established and for generating negative link established signals when a good link is not established. In a second group of embodiments, the receiver is adapted for determining whether a connection or link is established by determining whether a valid signal is present at the beginning and end of a timer cycle, the period of the timer being related to a typical duration of temporary signal losses during the negotiation process between devices, and for generating positive signals when a valid signal is present and negative signals when a valid signal is not present.

The network interfacing device further includes a cross-over switch which interconnects the signal paths defined by the connector with the receiver and the transmitter and control logic adapted for controlling the configuration of the switch as a function of a signal generated (e.g., a link established signal) by the receiver. The switch has a first position whereby the switch interconnects the receiver to the first signal path and the transmitter to the second signal path and a second position whereby the switch interconnects the receiver to the second signal path and the transmitter to the first signal path. In some embodiments, the control logic includes a timer which causes the switch to remain in its position for a period of time regardless of whether the signal is dropped temporarily within that period. The duration of the timer's cycle is preferably slightly longer than the typical period of time a carrier may temporarily drop off during the "negotiation" between devices to establish a good link.

In operation, the control logic sets the switch to one position and waits for a period of time T. In the first group of embodiments, the control logic subsequently detects the

state of the link established signal to determine whether a good link has been established. In the second group of embodiments, the control logic responds to the detection of a valid signal and its presence or lack of presence at the expiration of the timer to determine whether a link has been established. Typically, the receiver is characterized by a period of time t which is the time delay for the receiver to setup a network connection and report that a good link is established. Preferably, period of time T is a function of period of time t, for example, T is greater than or equal to t.

Alternatively, the network interfacing device can include a switch interconnecting the signal paths of a connector to a receiver and a transmitter and control logic for controlling the position of the switch as the function of a random or pseudo-random event. The control logic can include an element for generating a random bit (random event) and an element for determining whether the random bit is odd or even. The control logic can be adapted for setting the switch to a first position if the random bit is odd and for setting said switch to a second position if the random bit is even. The control logic can further be adapted for waiting for a period of time T after the switch is set and detecting the positive signal. In one embodiment, if the control logic detects that a good link is not established, the control logic can generate a new random bit and repeat the process. In another embodiment, if the control logic does not detect the presence of a valid signal, the control logic can generate a new random bit and repeat the process. Alternatively, before generating a new random bit, the control logic can be adapted to toggle the switch, wait for a period of time T, and detect whether a good link is established or a signal is detected.

In another embodiment, the network interfacing device can include a switch interconnecting the signal paths of a connector to a receiver and a transmitter and a control logic for controlling the position of the switch as the function of a random or pseudo-random event such as a random bit. The control logic can include an element for generating a random bit and an element for determining whether the random bit is odd or even. The control logic can further include a waveform generator adapted for generating a first waveform and a second waveform, different from the first waveform, each having a period that is a function of T and each having a first signal level and a second signal level. The time intervals of the first and second signal levels of the first waveform being different from the time intervals of the first and second signal levels of the second waveform. The

control logic is further adapted for setting the switch to the first position and the second position as a function of the signal levels of the waveform and for setting the switch to a set position as a function of the positive and negative signals.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects of this invention, the various features thereof, as well as the invention itself, may be more fully understood from the following description, when read together with the accompanying drawings in which:

FIG. 1 is a diagrammatic view of network connection showing a MDI and a MDI-X interface connected by a straight through cable;

FIG. 2 is a diagrammatic view of a network connection showing two MDI interfaces connected by a cross-over cable;

FIG. 3A is a diagrammatic view of a network interfacing device in accordance with present invention;

FIG. 3B is a diagrammatic view of the network interfacing device of FIG. 3A connected to a MDI interface by a straight through cable;

FIG. 3C is a diagrammatic view of two network interfacing devices of FIG. 3A connected by a cross-over cable;

FIGS. 4A and 4B are flow charts showing a method of controlling a cross-over switch in a network interfacing device in accordance with one embodiment of the present invention;

FIG. 5 is flow charts showing an alternate method of controlling a cross-over switch in a network interfacing device in accordance with one embodiment of the present invention;

FIG. 6 is flow charts showing an alternate method of controlling a cross-over switch in a network interfacing device in accordance with one embodiment of the present invention;

FIG. 7 is flow charts showing an alternate method of controlling a cross-over switch in a network interfacing device in accordance with one embodiment of the present invention;

FIG. 8 is a timing diagram of two waveforms for use in controlling the position of a cross-over switch in accordance with the present invention and the alternative method described by the flow chart in FIG. 7;

FIGS.9 is a flow chart showing a method of controlling a cross-over switch in a network interfacing device having a signal detection timer, in accordance with one embodiment of the present invention;

FIG. 10 is a flow chart showing an alternate method of controlling a cross-over switch in a network interfacing device having a signal detection timer, in accordance with one embodiment of the present invention;

FIG. 11 is a flow chart showing an alternate method of controlling a cross-over switch in a network interfacing device having a signal detection timer, in accordance with one embodiment of the present invention;

FIG. 12 is a flow chart showing an alternate method of controlling a cross-over switch in a network interfacing device having a signal detection timer, in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is directed to a network interfacing device such as a network interface adaptor or card (NIC), a network hub or switch or a media conversion device such as may be used in Ethernet local area networks (LANs). These network interfacing devices are typically interconnected by a network medium, such as unshielded twisted pair cable (UTP cable) in a point-to-point configuration. In order to establish a good link or network connection between the network interfacing devices, the network medium must connect the transmitter of the first device to the receiver of the second device and the transmitter of the second device to the receiver of the first device.

FIG. 1 shows a prior art point-to-point twisted pair Ethernet link using a straight through cable 10 to connect a network interfacing device 20, such as a NIC in unit of data terminal equipment (DTE), to a network interfacing device 30 in a network hub or repeater. Typically, each network interfacing device 20, 30 includes a connector 22, 32, such as an RJ45 connector. In order to establish a good link or network connection, the transmitter 24 of DTE device 20 must be electrically connected to the receiver 36 of the repeater device

30 and the transmitter 34 of the repeater device 30 must be electrically connected to the receiver 26 of the DTE device 20. Thus, one of the network interfacing devices (in this case the repeater device 30) must include cross-over wiring to enable a good link to be established. The interface at the DTE is a MDI interface and the crossed-over interface at the repeater is an MDI-X interface.

FIG. 2 shows a prior art point-to-point twisted pair Ethernet link using a cross-over cable 10 to connect a network interfacing device 20 (having an MDI interface) to a network interfacing device 30 (also having an MDI interface). As stated above, each network interfacing device 20, 30 includes a connector 22, 32, such as an RJ45 connector. In this configuration, a cross-over cable is required to insure that the transmitter 24 of DTE device 20 is connected to the receiver 36 of the repeater device 30 and the transmitter 34 of the repeater device 30 is connected to the receiver 26 of the DTE device 20 because both network interfacing devices are MDI interfaces. A crossover cable will also be required if both devices use an MDI-X interface.

FIG. 3A shows a configurable network interfacing device 100 in accordance with the present invention that includes an automatic cross-over system which senses whether a good link is established with a remote network interfacing device (not shown). In accordance with the preferred embodiments of the invention, the network interfacing device 100 is part of a NIC or network repeater or hub. The network interfacing device 100 includes a cross-over switch 140 which connects a connector 122, such as an RJ45 type connector, to the receiver 124 and the transmitter 126. The cross-over switch 140 can be set to one of two positions: 1) where the first data path 144 is connected to the transmitter 126 and the second data path 146 is connected to the receiver 124; or 2) where first data path is connected to the receiver 124 and the second data path is connected to the transmitter 126. The receiver 124 has the ability to generate a link established signal 128 indicating that a good link or network connection is established with the remote network interfacing device. The network interfacing device also includes control logic 150 which receives the link established signal 128 and generates a switch control signal 142 which controls the position of the cross-over switch 140. In operation, the control logic 150 controls the switch control signal 142 as a function of either a link established signal 128 (in a first group of embodiments) or alternatively a valid signal (not shown, in a second

group of embodiments) in order to control the position of the cross-over switch 140 and set the appropriate media interface. The switch control signal 142 can either toggle the switch (i.e., change the switch to the opposite position) or, preferably, set the switch to a specific or predefined position or sequence of positions as determined by a random or pseudo-random bit.

In the preferred embodiments, the network is an Ethernet LAN which uses UTP cable. The industry standard typically includes 4 twisted pair wires (8 conductors) which are connected to RJ45 connectors on both ends of the cable. As shown in FIGS.1 and 2, in accordance with the Ethernet Standard, only pins 1, 2, 3 and 6 are used. Pins 1 and 2 define one data path and pins 3 and 6 define the second data path. The diagrammatic view shown in FIG. 3A shows, for simplicity, the data paths 144 and 146 represented as a single line. However, as shown in FIGS.3B and 3C, the data paths 144 and 146 actually represent a twisted pair (2 conductors) and cross-over switch 140 actually includes two switches connected to each data path, one for each conductor.

In practice, the configurable network interfacing device 100 of FIG. 3A may be implemented at one or both ends of a link. For example, FIG. 3B shows a network system having a repeater and a DTE connected via a link and having a prior art MDI connector 22 as a DTE interface to the link and the configurable network interfacing device 100 as the repeater interface to the link. This configuration is similar to that shown in FIG. 1, except that the device 100, serving as an MDI adaptive device (MDI-A), is used in place of the MDI-X device. Data paths 144 and 146 comprise a prior art point-to-point twisted pair Ethernet link using a straight through cable. The cross-over switch 140 is shown having the switches in the proper position for establishing a good link, i.e., the transmitter 126 of the repeater is linked to the receiver 26 of the DTE and the receiver 124 of the repeater is linked to the transmitter 24 of the DTE. In this configuration, the MDI DTE network device 20 does not have adaptive capability, so will stay fixed as the MDI-A device 100 attempts to conFIG. itself to establish a good link between the devices. Given that the MDI-A device has adaptive capability, a priori knowledge of the configuration of the point-to-point link or DTE link interface are not required when connecting data paths 144 and 146 to MDI-A connector 122'.

As another example, FIG. 3C shows a network system having a repeater and a DTE connected via a link and having a MDI-A configurable network interfacing device as the DTE interface to the link and as the repeater interface to the link. This configuration is similar to that shown in FIG. 2, except that the MDI-A devices 100 and 100' are used in place of the MDI and MDI-X devices 20 and 30. Data paths 144' and 146' comprise a prior art point-to-point twisted pair Ethernet link using a cross-over cable. The cross-over switches 140 and 140' are shown in the proper position for establishing a good link, i.e., the transmitter 126 of the repeater is linked to the receiver 124' of the DTE and the receiver 124 of the repeater is linked to the transmitter 126' of the DTE. In this configuration, both the repeater and DTE network interfacing devices 100 and 100' have adaptive capability, so each will attempt to conFIG. itself to establish a good link between the devices. Given that each MDI-A device has adaptive capability, a priori knowledge of the configuration of the point-to-point link or remote devices is not required when connecting data paths 144' and 146' to MDI-A connector 122 or 122'.

In another embodiment, the control logic of at least one device 100 or 100' could be conFIG.d to determine whether a device having adaptive capability is used as the remote device. As a result of such a determination, the control logic 150 or 150' could also be conFIG.d to disable the switching capability of one of the devices 100 or 100', to possibly facilitate more quickly establishing a good link by stabilizing one end of the link while the other end attempts to adapt to the stable end. Alternatively, the switching end of one device 100 or 100' could be manually disabled to achieve similar results. In either case, the resulting configuration would be analogous to that shown in FIG. 3B.

In the preferred embodiments, cross-over switch 140 can be either a mechanical relay or a solid state relay or switch. Preferably, the cross-over switch 140 is a solid state switch, for example the P15L200 manufactured by Pericom Semiconductor Corp. of San Jose, California. Functions accomplished by control logic 150 can be performed by a circuit constructed from discrete components, by a programmable array logic device or by a microprocessor based system. Preferably, control logic 150 functions are performed by a CE 16V8H available from Advanced Micro Devices, Inc. of Sunnyvale, California.

The random or pseudo-random bits can be obtained by slow sampling of a fast but not stable oscillator, such as an oscillator that is not crystal controlled. In the preferred

embodiments, the pseudo-random bits are obtained by sampling a 1 MHz oscillator at 10 times a second (every 100,000 cycles nominally). The oscillator circuit is based upon the industry standard LM555CM timer/oscillator available from National Semiconductor of Santa Clara, California. Alternatively, the pseudo-random bits can be generated by sampling an amplified noise signal generated by a noise source such as a Zener diode.

FIGS.4A, 4B, 5, 6 and 7 show flow diagrams of four types of methods of controlling a cross-over switch to enable a network interfacing device to automatically conFIG. the interface (by setting or changing the cross-over switch position) to establish a network connection with a remote device in accordance with a first group of embodiments of the present invention. In each of the embodiments described below, the system must wait a period of time T before determining whether a good link has been established. Typically, the receiver is characterized by a period of time t which is the maximum amount of time needed by the receiver to establish a network connection and report that a good link has been established. Preferably, period of time T is a function of period of time t, as described further below.

FIGS.4A and 4B relate to a method which implements a "deterministic" approach for switch toggling and results in an established link in 2T, assuming only one interface device (or "node") is of the adaptive type, i.e., is "hunting" to establish a link. If both interface devices, one at each end of the link as in FIG. 3C, are hunting it is possible that the two ends will toggle more or less in step and a link will not be established. FIG. 5 relates to a method which overcomes the limitations of the deterministic approach by implementing a "random" approach for switch toggling. Under this approach, the average time required to establish a good link is 2T, independent of whether one or two ends of the link are hunting, but a good link is ultimately established. FIG. 6 relates to a hybrid method which implements a combination of the deterministic and random approaches, referred to as a "random manchester" approach for switch toggling. Under this approach, in each time period of 2T the system has a deterministic toggle, but with a random starting position. Therefore, if one node is hunting a link is established within 2T and if both nodes are hunting a link is established on average in 4T. Finally, FIG. 7 relates to a method which implements a "random pulse" approach for switch toggling. Under this approach, if one node is hunting a link is established within 4T and if both nodes are hunting and a

cross-over cable is used a link is established within 8T. If both nodes are hunting and a straight through cable is used the establishment of a link is random with an average time of 8T.

The table below is a summary of the properties of the different link configurations and different implementations of the control logic 150 of the configurable network interface device 100 according to the four types of approaches discussed. It gives the approximate worst case lock times for each link configuration and implementation.

	One Node Adaptive		Both Nodes Adaptive	
Cable type ->	Straight	Crossed-over	Straight	Crossed-over
Deterministic Toggle	Deterministic $\tau=2t$	Deterministic $\tau=2t$	Random- cannot be determined*	Random- cannot be determined*
Random Toggle	Random $E(\tau)=4t$	Random $E(\tau)=4t$	Random $E(\tau)=4t$	Random $E(\tau)=4t$
Random Manchester	Deterministic $\tau=4t$	Deterministic $\tau=4t$	Random $E(\tau)=8t$	Random $E(\tau)=8t$
Random Pulse Position	Deterministic $\tau=4t$	Deterministic $\tau=4t$	Random $E(\tau)=8t$	Deterministic $\tau=8t$

Table 1

Notes:

1) *Expected time to lock cannot be determined when both nodes are adaptive without knowing the relative frequencies of the two waveforms, one related to each node, wherein the expected lock time is approximately given by: $E(\tau)=t/\rho$ (where ρ is the relative frequency difference between the two waveforms).

2) τ represents the approximate worst case time to establish a link, $E(\tau)$ represents the expected average worst case time to establish a link, and t is the minimum time required to detect a good link.

As shown in FIG. 4A, the deterministic process 200 begins by changing the cross-over switch position 210 and waiting 215 a predetermined period of time T. Time T is a function of the time t required by the receiver of the network device to establish and report a network connection (herein referred to as a "good link"). Preferably, time T is greater than or equal to time t. After waiting for a time T, the control logic evaluates the link established signal 220 and determines whether a good link is established. If a good link is

not established, the process returns to step 210 where the cross-over switch position is changed and the process repeats until a connection is established and a good link detected. If a good link is established the process is finished. In this embodiment, if after a network connection is established, the network connection were to become broken, an external mechanism would be required to restart the process.

FIG. 4B shows an alternative process 250 to that shown in FIG. 4A which begins by changing the cross-over switch position 260 and waiting 265 a predetermined period of time T before evaluating the link established signal 270 to determine whether a good link is established. In this embodiment, if a good link is established, the process remains in a loop which checks the status of the link continuously or on a regular interval, preferably time T. As long as a good link is established, the position of the cross-over switch remains set. If the network connection should fail and the receiver reports that a good link is not established, the process resumes searching for the right configuration by changing the switch position 260 from one position to the other and vice versa, until a good link is established.

In the embodiments of FIGS.4A and 4B, the period of time T is a function of period of time t. Preferably, period of time T is greater than or equal to period of time t. This will allow the receiver sufficient time to establish a network connection and report a good link to the control logic. If period of time T is less than period of time t, it is likely that a the system will never stabilize into a cross-over switch position because the system will change the cross-over switch position before the receiver has been able to establish a network connection.

FIG. 5 shows an alternative process 300 for controlling a cross-over switch in accordance with the present invention. This process begins by getting a random bit 310 from a random bit generator. The next step 312 is to determine whether the random bit is odd or even. If the random bit is odd the cross-over switch is set to position 1 in step 314 and if the random bit is even the cross-over switch is set to position 2 in step 316. After the cross-over switch is set to either position, the system waits 318 for a period of time T in order to determine whether a good link can be established. If a good link is not established, the process returns to step 310 where a new random bit is obtained. If a good link is established at step 320 the process is finished. In this embodiment, if after a

network connection is established, the network connection were to become broken, an external mechanism would be required to restart the process. In an alternative embodiment, in step 320, if a good link is detected, the process could remain in a loop (in step 320) which checks the status of the link continuously or on a regular interval, preferably time T. In this embodiment, the period of time T is preferably greater than or equal to 2t.

FIG. 6 shows an alternative process 400 for controlling a cross-over switch in accordance with the present invention. This process 400 begins by getting a random bit 410 from a random bit generator. The next step 412 is to determine whether the random bit is odd or even. If the random bit is odd the cross-over switch is set to position 1 in step 414 and if the random bit is even the cross-over switch is set to position 2 in step 416. After the cross-over switch is set to either position, the system waits 418 for a period of time T in order to determine whether a good link can be established. If a good link is not established, the process continues at step 422 where the cross-over switch is toggled (i.e. changed from the current position to the opposite position) and the system waits 424 for a period of time T in order to determine whether a good link can be established. If a good link is not established at step 426, the process returns to step 410 where a new random bit is obtained. If a good link is established at step 426 the process is finished. In this embodiment, if after a network connection is established, the network connection were to become broken, an external mechanism would be required to restart the process. In an alternative embodiment, in both step 420 and step 426, if a good link is detected, the process could remain in a loop (in step 420 or 426) which checks the status of the link continuously or on a regular interval, preferably time T. In this embodiment, the period of time T is preferably greater than or equal to 2t.

FIG. 7 shows an alternative process 500 for controlling a cross-over switch in accordance with the present invention. This process 500 begins by getting a random bit 510 from a random bit generator. The next step 512 is to determine whether the random bit is odd or even. If the random bit is odd the system generates a first waveform type for a period of 4T at step 514 and if the random bit is even the system generates a second waveform type also for a period of 4T at step 516. If a good link is not established at step 518, the process returns to step 510 where a new random bit is obtained. If a good link is

established during the period of either waveform at step 518 the process sets the cross-over switch in the position that established the good link and process is finished. In this embodiment, if after a network connection is established, the network connection were to become broken, an external mechanism would be required to restart the process. In an alternative embodiment, in step 518, if a good link is detected, the process could remain in a loop (not shown) which checks the status of the link continuously or on a regular interval, preferably time T. In this embodiment, the period of time T is preferably greater than or equal to period of time t.

FIG. 8 shows the first waveform type 610 and second waveform type 620. Preferably, the period of each waveform is 4T, where period of time T is greater than or equal to period of time t. Each waveform is characterized by a high signal level portion and a low signal level portion. Preferably, at least the high signal level portion of each waveform extends for a duration of T and the high levels do not coincide during the same time interval over time period 4T. In this embodiment, the position of the cross-over switch is controlled by the level of the waveform.

In accordance with the preferred embodiments, the first waveform 610 includes a high signal level for a duration of time T followed by a low signal level for a duration of 3T. Preferably, the high signal level corresponds to the MDI-X interface and the low signal level corresponds to the MDI interface. The second waveform 620 includes a low signal level for a duration of 2T, followed by a high signal level for a duration of T, followed by a low signal level for a duration of T. Similarly, the high level corresponds to the MDI-X interface and the low level corresponds to the MDI interface.

Typically, a certain amount of "negotiation" takes place between the two devices attempting to establish a good link. In some cases, one device will "drop off" for a short period of time (e.g., 1.5 seconds) as part of the negotiation. In such a case, the configurable network interfacing device 100 of FIG. 3A employing one of the methods of FIGS.4A, 4B, 5, 6, and 7, may undesirably interpret such a temporary drop off as a termination of a good link, rather than that the link is in the process of coming up (i.e., getting established). Therefore, with regard to the flow diagrams of FIGS.9, 10, 11, and 12 a second group of embodiments derived from FIGS.4A and 4B, 5, 6, and 7, respectively, is shown. In the second group of embodiments, the control logic of the

configurable network interfacing device 100 is adapted to determine whether a good link has been established by determining whether a valid signal has been detected and, if so, allowing typical negotiation to complete before finally determining whether the link is established. Accordingly, a signal detection timer is embodied within the control logic which has a cycle time (or period) slightly greater (e.g., 2 seconds) than the duration of the period for which a device may "drop off" during negotiation (e.g., 1.5 seconds). Upon detection of a valid signal by the configurable network interfacing device 100, the timer is started. Generally speaking, if the signal drops off and comes back up before the timer is completed, an undesirable change in state of the switches within the configurable network interfacing device 100 will not take place.

FIG. 9 shows an alternative deterministic process 900 to that of FIGS.4A and 4B, which begins by changing the cross-over switch position 910 and waiting 912 a predetermined period of time T before evaluating 914 whether a valid signal is detected. In this embodiment, if a signal is detected, the process remains in a loop which checks the status of the link continuously or on a regular interval, preferably time T. If a valid signal is detected, the position of the cross-over switch remains set and a signal detection timer is started 916. Once the timer is started, another check to verify whether a signal is still present is performed 918. As long as the signal is present, the device 100 executes a loop whereby the timer is reset and started after each verification. If in step 918, the signal is not detected (i.e., it dropped off), a determination is made of whether the timer has expired 920.

If the timer has not expired in step 920, the switch position is held and another check is made to see whether the signal has returned 918. This loop continues until the timer has expired or a valid signal is once again detected. This delay in changing the state of the switch as a function of the signal detection timer to allow the valid signal to settle, may notionally be considered as adding hysteresis to the system. If the signal is not detected when the timer has expired, the device 100 determines that the link was not established and changes the switch position 910 and repeats the process. This process continues to execute indefinitely, to provide a constant check of link status. In an alternative form, process 900 could be modified such that it terminates execution if a valid

signal is present when the timer expires. In such a case, the process could be started at step 910 by an external mechanism should the good link become disestablished.

As with the previous embodiments, in the embodiments of FIGS.9, 10 and 11 the period of time T is a function of period of time t and the relationships of Table 1 hold true. Preferably, period of time T is greater than or equal to the period of time t for the methods described with respect to FIGS.9 and 12 and greater than or equal to 2t for the methods described with respect to FIGS.10 and 11. Wherein, t is the minimum time required to detect a good link. This will allow the receiver sufficient time to establish an initial network connection and begin negotiation between devices. If period of time T is less than period of time t, it is likely that the system will never stabilize into a cross-over switch position because the system will change the cross-over switch position before the receiver has been able to establish a network connection.

FIG. 10 shows an alternative random process 1000 to that of FIG. 5 for controlling a cross-over switch in accordance with the present invention. This process begins by getting a random bit 1002 from a random bit generator. The next step 1004 is to determine whether the random bit is odd or even. If the random bit is odd the cross-over switch is set to position 1 in step 1006 and if the random bit is even the cross-over switch is set to position 2 in step 1018. After the cross-over switch is set to either position, the system waits 1008 for a period of time T before it determines whether a valid signal is detected. If a valid signal is not detected in step 1010, the process returns to step 1002 where a new random bit is obtained and the process is restarted. If a valid signal is detected at step 1010 the process continues and a signal detection timer is started in step 1012.

The period of the timer is set to be equal to or marginally greater than a typical drop off period during negotiation of two communication devices attempting to establish a good link. Once the timer has started the system enters a loop, wherein a check is performed to determine if the valid signal is still present, in step 1014. If the valid signal is still present, the system returns to step 1012 and restarts the timer. As long as the signal is present this loop continues to execute. If in step 1014 a valid signal is no longer detected, the process continues to step 1016 where a check is performed to determine whether the timer has expired. As long as the timer has not expired the system returns to step 1014 to see if the valid signal has returned. If, in step 1016, the timer has expired with no valid signal

present the system repeats the process by returning to step 1002 and getting another random bit. In an alternative embodiment of this process, if the timer is not reset from step 1014 and a valid signal is detected when the timer expires, the process could be terminated and restarted by an external mechanism, should the link become disestablished.

FIG. 11 shows an alternative random manchester process 1100 to that of FIG. 6 for controlling a cross-over switch in accordance with the present invention. This process 1100 begins by getting a random bit 1102 from a random bit generator. The next step 1104 is to determine whether the random bit is odd or even. If the random bit is odd the cross-over switch is set to position 1 in step 1106 and if the random bit is even the cross-over switch is set to position 2 in step 1116. After the cross-over switch is set to either position, the system waits 1108 for a period of time T in order to determine whether a valid signal is detected. If a valid signal is not detected, the process continues at step 1122 where the cross-over switch is toggled (i.e., changed from the current position to the opposite position) and the system waits 1118 for a period of time T in order to determine whether a valid signal is present. If a valid is not present at step 1120, the process returns to step 1102 where a new random bit is obtained. If a valid signal is detected at step 1120 the process continues to execute a loop which monitors the link's status. That is, in step 1112 a signal detection timer is started, which is similar to the timer of FIGS.9 and 10.

Once the timer is started, a check is performed to see whether any valid signal is still detected in step 1114. If a valid signal is detected, the process returns to step 1112 where the timer is reset and started again. If a valid signal was not detected in step 1114, the process continues to step 1124 to determine whether the timer has expired. If the timer has not expired, the process returns to step 1114 to determine whether a valid signal is present again. If the timer has expired in step 1124 and a valid signal is not present, the process returns to step 1102 and begins again. In an alternative form of this process, if the timer is not reset from step 1114 and a valid signal was present when the timer expired the process could be terminated and restarted by an external mechanism, should the link become disestablished.

FIG. 12 shows an alternative random pulse position process 1200 to that of FIG. 7 for controlling a cross-over switch in accordance with the present invention. This process 1200 begins by getting a random bit 1202 from a random bit generator. The next step 1204

is to determine whether the random bit is odd or even. If the random bit is odd the system generates a first waveform type for a period of 4T at step 1206 and if the random bit is even the system generates a second waveform type also for a period of 4T at step 1214. In the preferred embodiments these waveforms are those described with regard to FIG. 8. If a valid signal is not present at step 1208, the process returns to step 1202 where a new random bit is obtained. If a valid signal is present during the period of either waveform at step 1208 the process sets the cross-over switch in the position that established the valid signal and the process continues and starts a signal detection timer in step 1210.

Once the timer is started in step 1210, a determination is made of whether a valid signal still exists, in step 1212. If a valid signal does exist, the process returns to step 1210 where the timer is reset and started again. In this way, the process continues monitoring the link. If a valid signal is no longer detected in step 1212, the process continues to step 1216 to determine whether the timer has expired. If it has not, the process returns to step 1212 to determine whether the signal has returned. If a valid signal was not detected and the timer expired, the process continues to step 1202 to repeat. In an alternative form, the timer does not reset from step 1212 and the process could terminate if a valid signal were present when the timer expired. In such a case, the process could be restarted by an external mechanism should the link become disestablished.

As a person having ordinary skill in the art will appreciate, while the examples provided above include a cross-over switch which includes only two positions, the invention can readily be adapted to devices where the cross-over switch has more than two positions to accommodate devices that can have more than two possible interface configurations. In these embodiments, the control logic would be adapted to either change the cross-over switch to a specific position or to merely change the switch from one position to the next in a series of successive positions. Similarly, the methods described above would be adapted to search each of the possible interface configurations by changing the cross-over switch position from one position to another either in a preprogrammed or predefined order sequence or in a random sequence until a network connection is established.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be

considered in respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of the equivalency of the claims are therefore intended to be embraced therein.

What is claimed is

1. A network interface device comprising:

a connector, having a plurality of signal paths, adapted for connecting a plurality of signals to said network interface device;

a receiver adapted for receiving signals from a first signal path and for generating a positive signal when a valid signal is detected and a negative signal when a valid signal is not detected;

a transmitter adapted for transmitting signals over a second signal path;

a switch having a first position whereby said switch is adapted for interconnecting said first signal path to said receiver and said second signal path to said transmitter and a second position whereby said switch is adapted for interconnecting said first signal path to said transmitter and said second signal path to said receiver; and

control logic including:

a first detection means for detecting said positive and negative signals and for starting a signal detection timer having a fixed period upon detection of said positive signal and for changing said switch from one of said first position and said second position to the other of said first position and said second position in response to said negative signal;

a second detection means for detecting said positive signal, in response to the starting of said signal detection timer, wherein said second detection means restarts said signal detection timer in response to detection of a positive signal;

means for determining whether said signal detection timer fixed period has expired; and

means for changing said switch from one of said first position and said second position to the other of said first position and said second position as a function of whether the timer has expired.

2. A network interface device according to claim 1 wherein:

said control logic is adapted for detecting said valid signal and for not changing said switch from one of said first position and said second position to the other of said first position and said second position in response to said positive signal.

3. A network interface device according to claim 1 further comprising

delay means for causing a delay for a period of time T before detecting said positive and negative signals.

4. A network interface device according to claim 3 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is a function of said period of time t.

5. A network interface device according to claim 4 wherein said T is greater than or equal to t.

6. A network interface device according to claim 1 wherein said first signal path includes a first twisted pair of wires and said second signal path includes a second twisted pair of wires.

7. A network interface device according to claim 1 wherein

said receiver is local area network (LAN) receiver and said switch conFIGS.said network interface device whereby

when said switch is in said first position, said network interface device conforms to a media dependent interface (MDI); and

when said switch is in said second position, said network interface device conforms to a media dependent interface - crossed over (MDI-X).

8. A network interface device comprising

a connector, having a plurality of signal paths, adapted for connecting a plurality of signals to said network interface device;

a receiver adapted for receiving signals from a first signal path and for generating a positive signal when a valid signal is detected and a negative signal when a valid signal is not detected;

a transmitter adapted for transmitting signals over a second signal path;

a switch having a first position whereby said switch is adapted for interconnecting said first signal path to said receiver and said second signal path to said transmitter and a second position whereby said switch is adapted for interconnecting said first signal path to said transmitter and said second signal path to said receiver; and

control logic including:

means for generating a random bit;

means for determining whether said random bit is odd or even;

means for setting said switch to said first position if said random bit is odd and for setting said switch to said second position if said random bit is even;

means for waiting for a period of time T after said switch is set to either said first position or said second position;

a first detection means for detecting said positive and negative signals;

means for starting a signal detection timer having a fixed period in response to detection of said positive signal by said first detection means;

means for generating another random bit as a function of detection of said negative signals by said first detection means;

a second detection means for detecting said positive signal, in response to the starting of said signal detection timer, wherein said second detection means restarts said signal detection timer in response to detection of said positive signal;

means for determining whether said signal detection timer fixed period has expired in response to a detection of said negative signal; and

means for generating another random bit as a function of whether the timer has expired.

9. A network interface device according to claim 8 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is a function of said period of time t.

10. A network interface device according to claim 9 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is greater than or equal to 2t.

11. A network interface device according to claim 8 wherein said control logic further comprises:

means for changing said switch from one of said first position and said second position to the other of said first position and said second position as function of not detecting said valid signal.

12. A network interface device according to claim 8 wherein said first signal path includes a first twisted pair of wires and said second signal path includes a second twisted pair of wires.

13. A network interface device according to claim 8 wherein

said receiver is local area network (LAN) receiver and said switch conFIGS.said network interface device whereby

when said switch is in said first position, said network interface device conforms to a media dependent interface (MDI); and

when said switch is in said second position, said network interface device conforms to a media dependent interface - crossed over (MDI-X).

14. A network interfacing device comprising:

a connector, having a plurality of signal paths, adapted for connecting a plurality of signals to said network interface device;

a receiver adapted for receiving signals from a first signal path and for generating a positive signal when a valid signal is detected and a negative signal when a valid signal is not detected, said receiver being characterized by a period of time t for generating said positive and negative signals;

a transmitter adapted for transmitting signals over a second signal path;

a switch having a first position whereby said switch is adapted for interconnecting said first signal path to said receiver and said second signal path to said transmitter and a second position whereby said switch is adapted for interconnecting said first signal path to said transmitter and said second signal path to said receiver;

a control logic including :

means for generating a random bit;

means for determining whether said random bit is odd or even;

means for setting said switch to said first position or said second position as a function of whether said random bit is odd or even;

a first detection means for detecting said positive and negative signals;

means for starting a signal detection timer having a fixed period in response to detection of said positive signal by said first detection means;

means for toggling the switch from its set first or second position to the other of the first or second position, in response to detection of said negative signal by said first detection means;

a second detection means for detecting a positive signal in response to said toggling of said switch position and for starting said signal detection timer in response to detection of said positive signal by said second detection means;

a third detection means for detecting said positive signal in response to the starting of said signal detection timer, wherein said third detection means restarts said signal detection timer in response to detection of said positive signal by said third detection means;

means for determining whether said signal detection timer fixed period has expired; and

means for generating another random bit as a function of whether the timer has expired.

15. A network interface device according to claim 14 further comprising:

delay means for causing a delay for a period of time T before detecting said positive and negative signals.

16. A network interface device according to claim 15 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is a function of said period of time t.

17. A network interface device according to claim 16 wherein said T is greater than or equal to 2t.

18. A network interface device according to claim 14 wherein

said receiver is local area network (LAN) receiver and said switch conFIGS.said network interface device whereby

when said switch is in said first position, said network interface device conforms to a media dependent interface (MDI); and

when said switch is in said second position, said network interface device conforms to a media dependent interface - crossed over (MDI-X).

19. A network interfacing device comprising:

a connector, having a plurality of signal paths, adapted for connecting a plurality of signals to said network interface device;

a receiver adapted for receiving signals from a first signal path and for generating a positive signal when a valid signal is detected and a negative signal when a valid signal is not detected, said receiver being characterized by a period of time t for generating said positive and negative signals;

a transmitter adapted for transmitting signals over a second signal path;

a switch having a first position whereby said switch is adapted for interconnecting said first signal path to said receiver and said second signal path to said transmitter and a second position whereby said switch is adapted for interconnecting said first signal path to said transmitter and said second signal path to said receiver;

a control logic including :

means for generating a random bit;

means for determining whether said random bit is odd or even;

waveform generating means for generating a first waveform having a period 4T, wherein T is greater than t, and having at least two signal levels over said period 4T and for generating a second waveform, different from said first waveform, having a period 4T, wherein T is greater than t, and having at least two signal levels over said period 4T at different time intervals than said first waveform;

means for setting said waveform generating means to generate said first waveform if said random bit is odd and for setting said waveform generating means to generate said second waveform if said random bit is even;

means for setting said switch to said first position and said second position as a function of said first level and said second level of the waveform generated by said waveform generating means;

a first detection means for detecting said positive and negative signals;

means for starting a signal detection timer having a fixed period in response to detection of said positive signal by said first detection means;

a second detection means for detecting said positive signal in response to the starting of said signal detection timer, wherein said second detection means restarts said signal detection timer in response to detection of said positive signal;

means for determining whether said signal detection timer fixed period has expired; and

means for generating another random bit as a function of whether the timer has expired.

20. A network interface device according to claim 19 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is a function of said period of time t.

21. A network interface device according to claim 20 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is greater than or equal to t.

22. A network interface device according to claim 19 wherein said first signal path includes a first twisted pair of wires and said second signal path includes a second twisted pair of wires.

23. A network interface device according to claim 19 wherein

said receiver is local area network (LAN) receiver and said switch conFIGS.said network interface device whereby

when said switch is in said first position, said network interface device conforms to a media dependent interface (MDI); and

when said switch is in said second position, said network interface device conforms to a media dependent interface - crossed over (MDI-X).

24. A network interfacing device comprising:

a media interface, defining a plurality of signal paths, adapted for connecting said network interfacing device to a network medium, said media interface being selectively configurable to provide a first type of media interface and a second type of media interface;

a receiver adapted for receiving signals from a first signal path and for generating a positive signal when a valid signal is established and a negative signal when a valid signal is not established; and

control logic adapted for detecting said positive and negative signals and for changing said media interface from one type of media interface and another type of media interface as a function of said positive and negative signals.

25. A network interface device according to claim 24 further comprising

delay means for defining a delay state which includes a delay for a period of time T before positive and negative signals are detected and a detect state during which positive and negative signals can be detected; and wherein

said control logic is adapted for detecting said positive and negative signals and for changing said media interface from one type of media interface and another type of media interface as a function of said positive and negative signals and said state of said delay means.

26. A network interface device according to claim 25 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is a function of said period of time t.

27. A network interface device according to claim 24 wherein:

said receiver is local area network (LAN) receiver;

said first media interface is a media dependent interface (MDI); and

said second media interface is a media dependent interface - crossed over (MDI-X).

28. In a network interface device, a method of controlling a cross-over switch having a first position and a second position, said method comprising the steps of:

setting said cross-over switch to one of said first position and said second position;

waiting a predefined period of time T;

determining whether a valid signal has been detected;

changing said cross-over switch from said one of said first position and said second position to the other of said first position and said second position if a valid

signal has not been detected.

29. In a network interface device, a method of controlling a cross-over switch according to claim 28 wherein said network interface device includes a receiver and said receiver is characterized by a period of time t for determining whether a valid signal has been detected and said period of time T is a function of said period of time t.

30. In a network interface device, a method of controlling a cross-over switch having a first position and a second position, said method comprising the steps of:

A) setting said cross-over switch position to either of said first or second position;

B) waiting a predefined period of time T;

C) determining whether a valid signal is detected;

D) starting a timer having a fixed period if a valid signal is detected or, alternatively, repeating steps A - D until a valid signal is detected.

E) determining whether the valid signal is detected, once the timer is started, and restarting the timer if said valid signal is detected;

F) determining whether said timer fixed period has expired, if a valid signal was not detected in step E; and

G) returning to step E if said timer fixed period has not expired or repeating steps A - G if said timer fixed period has expired.

31. In a network interface device, a method of controlling a cross-over switch according to claim 30 wherein said network interface device includes a receiver and said receiver is characterized by a period of time t for determining whether a valid signal has been detected and said period of time T is a function of said period of time t.

32. In a network interface device, a method of controlling a cross-over switch according to claim 31 wherein said period of time T is greater than or equal to t.

33. In a network interface device, a method of controlling a cross-over switch according to claim 30 wherein step A comprises the steps of:

A-1) changing said cross-over switch from one of said first position and said second position to the other of said first position and said second position if a valid signal is not detected.

34. In a network interface device, a method of controlling a cross-over switch according to claim 30 wherein step A comprises the steps of:

A-1) generating a random bit;

A-2) determining whether said bit is odd or even; and

A-3) setting said cross-over switch to said first position if said random bit is odd or setting said cross-over switch to said second position if said random bit is even.

35. In a network interface device, a method of controlling a cross-over switch according to claim 34 wherein said network interface device includes a receiver and said receiver is characterized by a period of time t for determining whether a valid signal is detected and said period of time T is a function of said period of time t.

36. In a network interface device, a method of controlling a cross-over switch according to claim 31 wherein said period of time T is greater than or equal to 2t.

37. In a network interface device, a method of controlling a cross-over switch having a first position and a second position, said method comprising the steps of:

A) generating a random bit;

B) determining whether said bit is odd or even;

C) setting, if said random bit is odd, said switch to said first position;

D) setting, if said random bit is even, said switch to said second position;

E) determining whether a valid signal is detected;

F) starting a timer having a fixed period if a valid signal is detected in step E and proceeding to step I;

G) toggling said set switch to the other of said first and second positions if a valid signal is not detected in step E and determining whether a valid signal is detected;

H) returning to step A if a valid signal is not detected in step G or, alternatively, starting said signal detection timer if a valid signal is detected;

I) determining whether the valid signal is detected, once the timer is started, and restarting the timer if said valid signal is detected;

J) determining whether said timer fixed period has expired, if a valid signal was not detected in step I; and

K) returning to step I if said timer fixed period has not expired or repeating steps A-K said timer fixed period has expired.

38. In a network interface device, a method of controlling a cross-over switch according to claim 37 wherein said network interface device includes a receiver and said receiver is characterized by a period of time t for determining whether a valid signal is detected and said period of time T is a function of said period of time t.

39. In a network interface device, a method of controlling a cross-over switch according to claim 38 wherein said period of time T is greater than or equal to 2t.

40. In a network interface device, a method of controlling a cross-over switch having a first position and a second position, said method comprising the steps of:

A) generating a random bit;

B) determining whether said bit is odd or even;

C) generating, if said random bit is odd, a first waveform having a period 4T and having at least two signal levels over said period 4T or generating, if said random bit is even, a second waveform, different from said first waveform, having a period 4T and having at least two signal levels over said period 4T at different time intervals than said first waveform;

D) setting said switch to said first position and said second position as a function of said two signal levels of said generated waveform;

E) determining whether a valid signal is detected;

F) starting a timer having a fixed period if a valid signal is detected or, alternatively, repeating steps A - F until a valid signal is detected;

G) determining whether the valid signal is detected, once the timer is started, and restarting the timer if said valid signal is detected;

H) determining whether said timer fixed period has expired, if a valid signal was not detected in step G; and

I) returning to step G if said timer fixed period has not expired or repeating steps A-I if said timer fixed period has expired.

41. In a network interface device, a method of controlling a cross-over switch according to claim 40 wherein said network interface device includes a receiver and said receiver is characterized by a period of time t for determining whether a valid signal is detected and said period of time T is a function of said period of time t.

42. In a network interface device, a method of controlling a cross-over switch according to claim 41 wherein said period of time T is greater than or equal to t.

43. An adaptive networked system, comprising:

a first network device having a transmitter and a receiver;

a second network device having a transmitter and a receiver;

a communication link having at least a first data path and a second data path;

a first network interface device, which interfaces the first network device to the communication link, wherein the first interface device is capable of:

a. automatically connecting the transmitter of the first network device to the first data path when the first data path is connected to the receiver of the second network device and connecting the receiver of the first network device to the second data path when the second data path is connected to the transmitter of the second network device; and

b. automatically connecting the transmitter of the first network device to the second data path when the second data path is connected to the

receiver of the second network device and connecting the receiver of the first network device to the first data path when the first data path is connected to the transmitter of the second network device; and

a second network interface device, which interfaces the second network device to the communication link.

44. The adaptive networked system of Claim 43 wherein the first interface device is configurable as a MDI interface and, alternatively, as a MDI-X interface.

45. The adaptive networked system of Claim 43, wherein the receiver of the first network device and the receiver of the second network device are adapted for generating a signal indicative of the establishment of a link between said first and second network devices and wherein the first interface device includes:

a. a switch having a first position whereby said switch connects the transmitter of said first network device to the first data path and connects the receiver of the first network device to the second data path and having a second position whereby said switch connects the transmitter of said first network device to the second data path and connects the receiver of the first network device to the first data path; and

b. a control logic adapted for detecting said signal and positioning the switch to one of said first or second positions in response thereto.

46. The adaptive networked system of Claim 43, wherein the second network interface device is capable of:

a. automatically connecting the transmitter of the second network device to the first data path when the first data path is connected to the receiver of the first network device and connecting the receiver of the second network device to the second data path when the second data path is connected to the transmitter of the first network device; and

b. automatically connecting the transmitter of the second network device to the second data path when the second data path is connected to the receiver of

the first network device and connecting the receiver of the second network device to the first data path when the first data path is connected to the transmitter of the first network device.

47. The adaptive networked system of Claim 46 wherein the second interface device is configurable as a MDI interface and, alternatively, as a MDI-X interface.

48. The adaptive networked system of Claim 46, wherein the receiver of the first network device and the receiver of the second network device are adapted for generating a signal indicative of the establishment of a link between said first and second network devices and wherein the second interface device includes:

a. a switch having a first position whereby said switch connects the transmitter of said second network device to the first data path and connects the receiver of the second network device to the second data path and having a second position whereby said switch connects the transmitter of said second network device to the second data path and connects the receiver of the second network device to the first data path; and

b. a control logic adapted for detecting said signal and positioning the switch to one of said first or second positions in response thereto.

49. The adaptive networked system of Claim 43 wherein the communication link is a point-to-point twisted pair Ethernet link.

50. The adaptive networked system of Claim 43 wherein the communication link is a straight through cable.

51. The adaptive networked system of Claim 43 wherein the communication link is a cross-over cable.

52. The adaptive networked system of Claim 43 wherein the first and second network interface devices each include a RJ45 connector as an interface to the communication link.

53. The adaptive networked system of Claim 43 wherein the first network device is a repeater.

54. The adaptive networked system of Claim 43 wherein the second network device is a data terminal equipment device.

AMENDED CLAIMS

[received by the International Bureau on 25 July 2000 (25.07.00); original claims 7, 13, 18 and 23 amended; remaining claims unchanged (4 pages)]

2. A network interface device according to claim 1 wherein:

said control logic is adapted for detecting said valid signal and for not changing said switch from one of said first position and said second position to the other of said first position and said second position in response to said positive signal.

3. A network interface device according to claim 1 further comprising

delay means for causing a delay for a period of time T before detecting said positive and negative signals.

4. A network interface device according to claim 3 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is a function of said period of time t.

5. A network interface device according to claim 4 wherein said T is greater than or equal to t.

6. A network interface device according to claim 1 wherein said first signal path includes a first twisted pair of wires and said second signal path includes a second twisted pair of wires.

7. A network interface device according to claim 1 wherein

said receiver is local area network (LAN) receiver and said switch configures said network interface device whereby

when said switch is in said first position, said network interface device conforms to a media dependent interface (MDI); and

when said switch is in said second position, said network interface device conforms to a media dependent interface - crossed over (MDI-X).

means for determining whether said signal detection timer fixed period has expired in response to a detection of said negative signal; and

means for generating another random bit as a function of whether the timer has expired.

9. A network interface device according to claim 8 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is a function of said period of time t.

10. A network interface device according to claim 9 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is greater than or equal to 2t.

11. A network interface device according to claim 8 wherein said control logic further comprises:

means for changing said switch from one of said first position and said second position to the other of said first position and said second position as function of not detecting said valid signal.

12. A network interface device according to claim 8 wherein said first signal path includes a first twisted pair of wires and said second signal path includes a second twisted pair of wires.

13. A network interface device according to claim 8 wherein

said receiver is local area network (LAN) receiver and said switch configures said network interface device whereby

when said switch is in said first position, said network interface device conforms to a media dependent interface (MDI); and

when said switch is in said second position, said network interface device conforms to a media dependent interface - crossed over (MDI-X).

means for determining whether said signal detection timer fixed period has expired; and

means for generating another random bit as a function of whether the timer has expired.

15. A network interface device according to claim 14 further comprising:

delay means for causing a delay for a period of time T before detecting said positive and negative signals.

16. A network interface device according to claim 15 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is a function of said period of time t.

17. A network interface device according to claim 16 wherein said T is greater than or equal to 2t.

18. A network interface device according to claim 14 wherein

said receiver is local area network (LAN) receiver and said switch configures said network interface device whereby

when said switch is in said first position, said network interface device conforms to a media dependent interface (MDI); and

when said switch is in said second position, said network interface device conforms to a media dependent interface - crossed over (MDI-X).

19. A network interfacing device comprising:

a connector, having a plurality of signal paths, adapted for connecting a plurality of signals to said network interface device;

a receiver adapted for receiving signals from a first signal path and for generating a positive signal when a valid signal is detected and a negative signal when a valid signal is not detected, said receiver being characterized by a period of time t for generating said positive and negative signals;

means for generating another random bit as a function of whether the timer has expired.

20. A network interface device according to claim 19 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is a function of said period of time t.

21. A network interface device according to claim 20 wherein said receiver is characterized by a period of time t for generating said positive and negative signals and said period of time T is greater than or equal to t.

22. A network interface device according to claim 19 wherein said first signal path includes a first twisted pair of wires and said second signal path includes a second twisted pair of wires.

23. A network interface device according to claim 19 wherein

said receiver is local area network (LAN) receiver and said switch configures said network interface device whereby

when said switch is in said first position, said network interface device conforms to a media dependent interface (MDI); and

when said switch is in said second position, said network interface device conforms to a media dependent interface - crossed over (MDI-X).

24. A network interfacing device comprising:

a media interface, defining a plurality of signal paths, adapted for connecting said network interfacing device to a network medium, said media interface being selectively configurable to provide a first type of media interface and a second type of media interface;

a receiver adapted for receiving signals from a first signal path and for generating a positive signal when a valid signal is established and a negative signal when a valid signal is not established; and

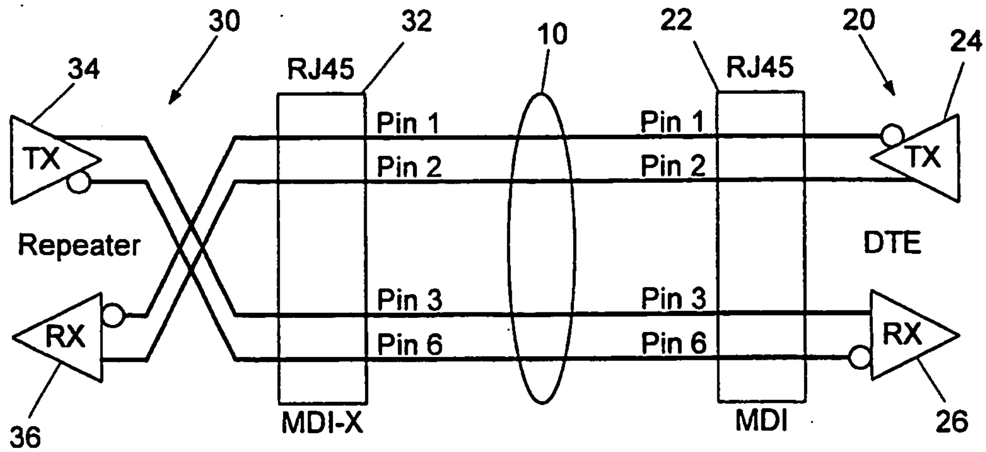


FIG. 1
Prior Art

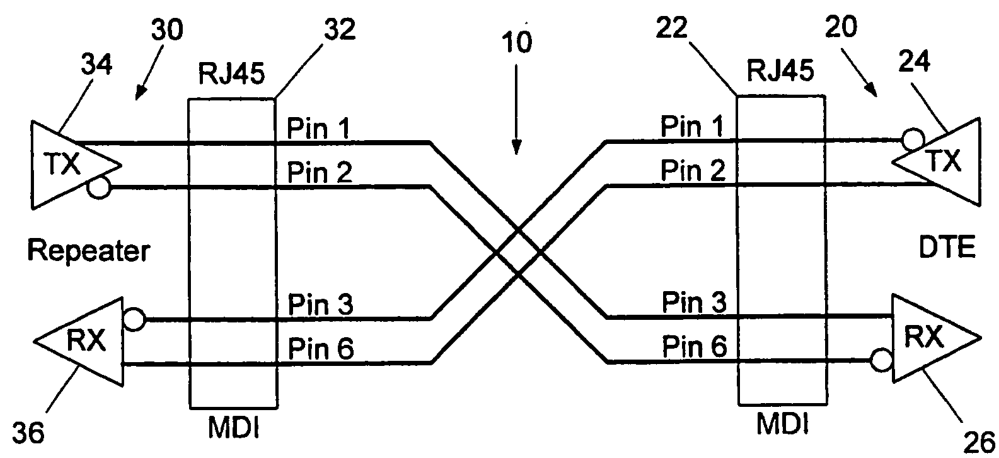


FIG. 2
Prior Art

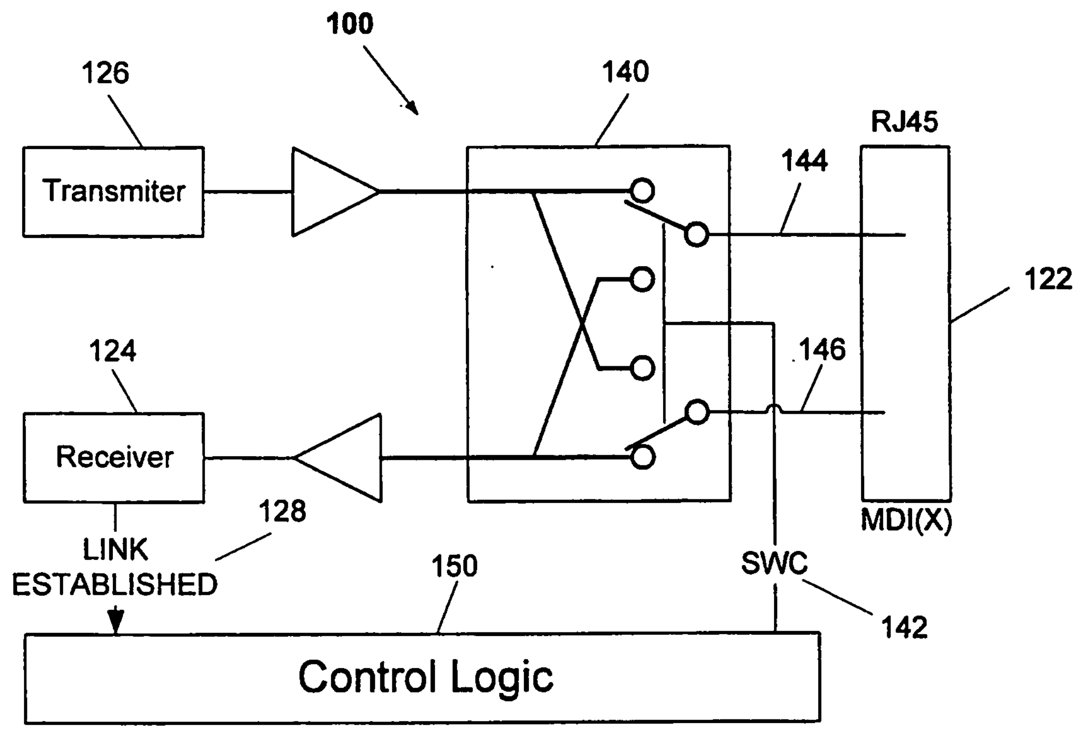

100
126
140
RJ45
144
Transmiter
122
124
146
Receiver
128
MDI(X)
LINK
ESTABLISHED
150
SWC
142
Control Logic

FIG. 3A

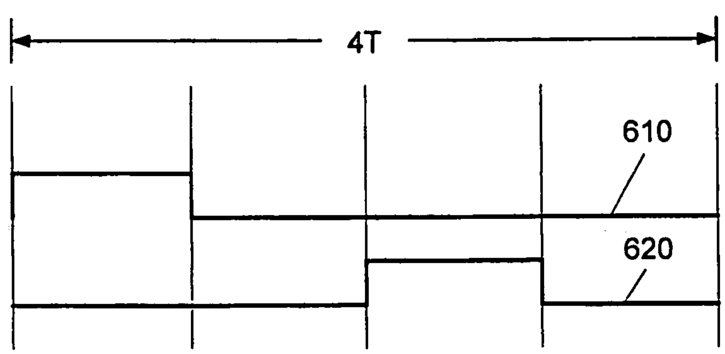

4T
610
620

FIG. 8

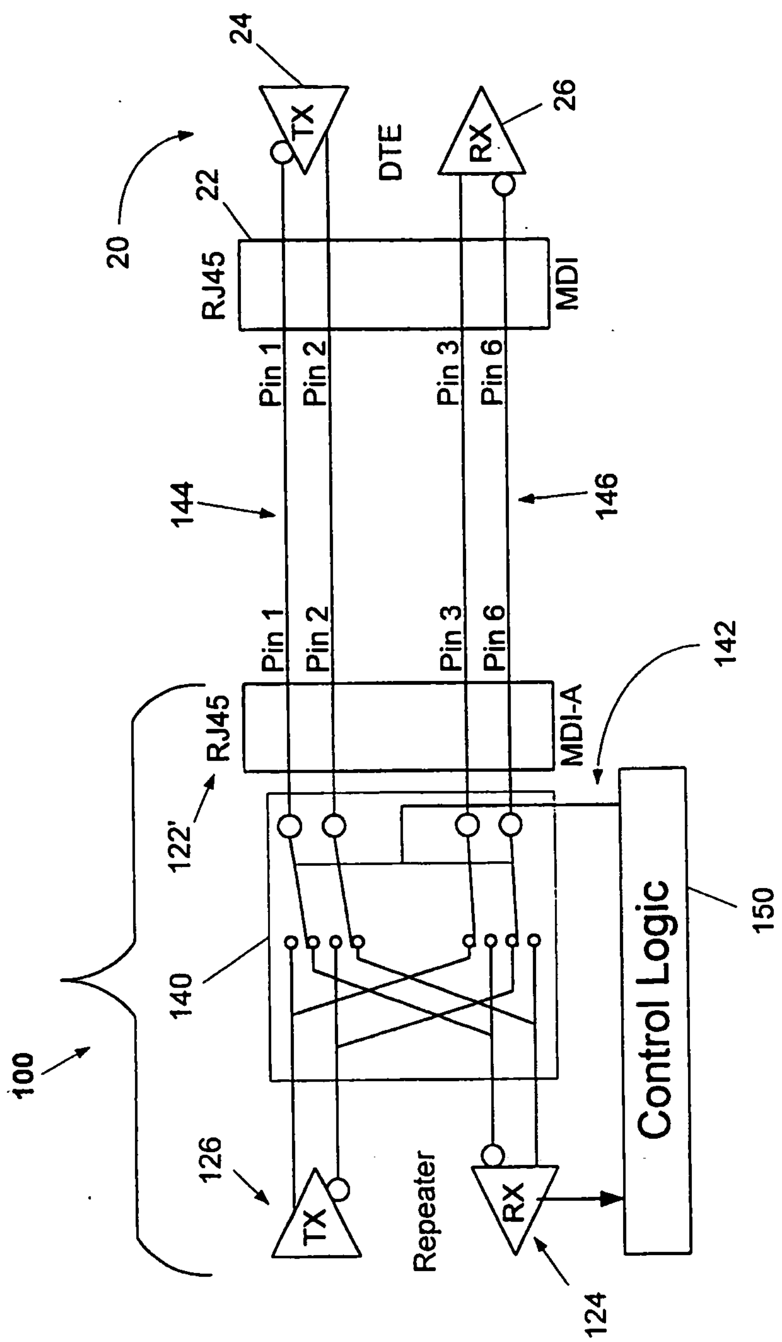

24
TX
DTE
RX
26
20
22
RJ45
MDI
Pin 1
Pin 2
Pin 3
Pin 6
144
146
Pin 1
Pin 2
Pin 3
Pin 6
RJ45
MDI-A
142
122'
Control Logic
150
140
100
126
TX
Repeater
RX
124

FIG. 3B

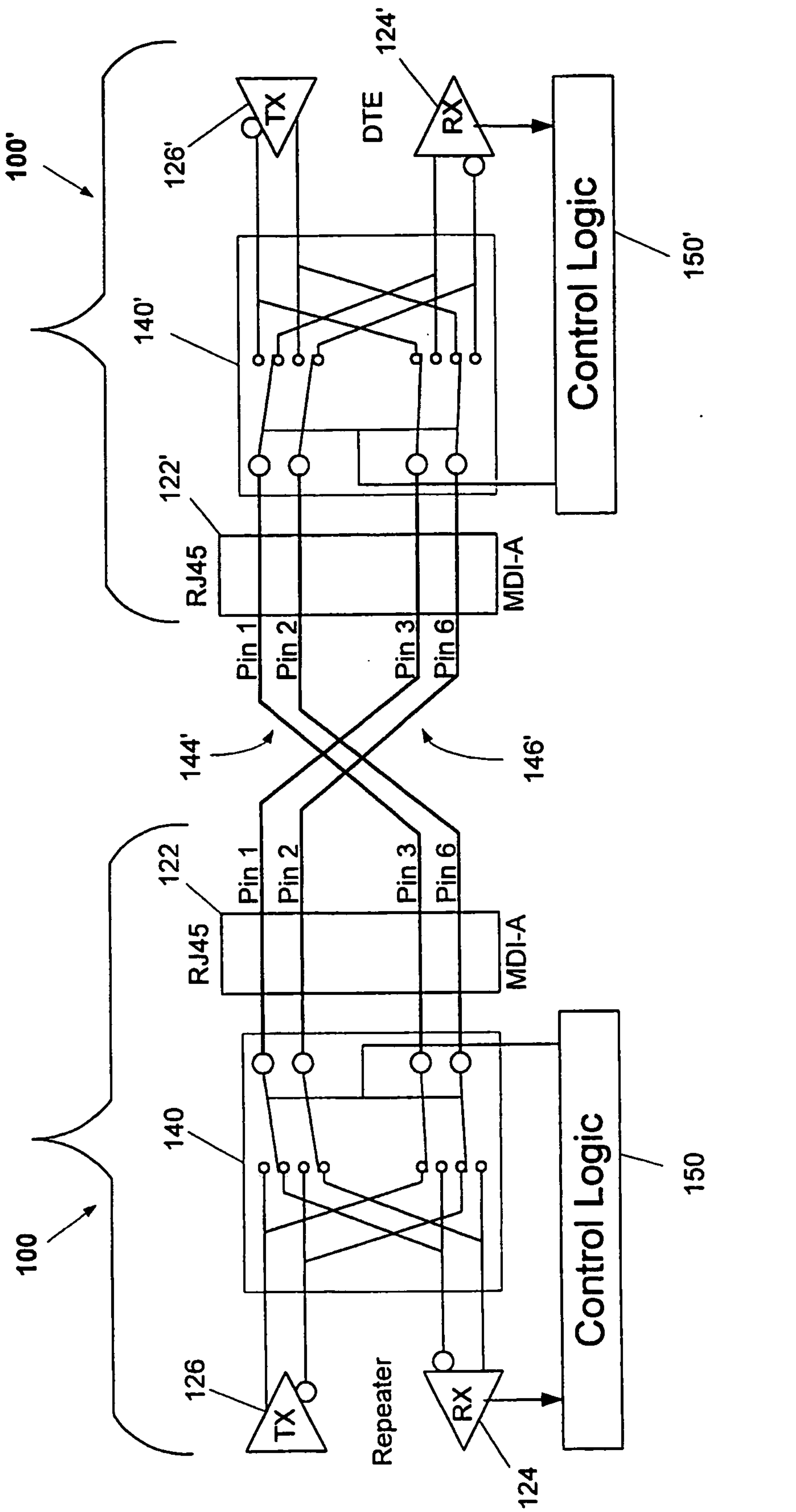

100'
124'
126'
TX
DTE
RX
140'
Control Logic
150'
122'
RJ45
MDI-A
Pin 1
Pin 2
Pin 3
Pin 6
144'
146'
122
Pin 1
Pin 2
Pin 3
Pin 6
RJ45
MDI-A
140
100
Control Logic
150
126
TX
Repeater
RX
124

FIG. 3C

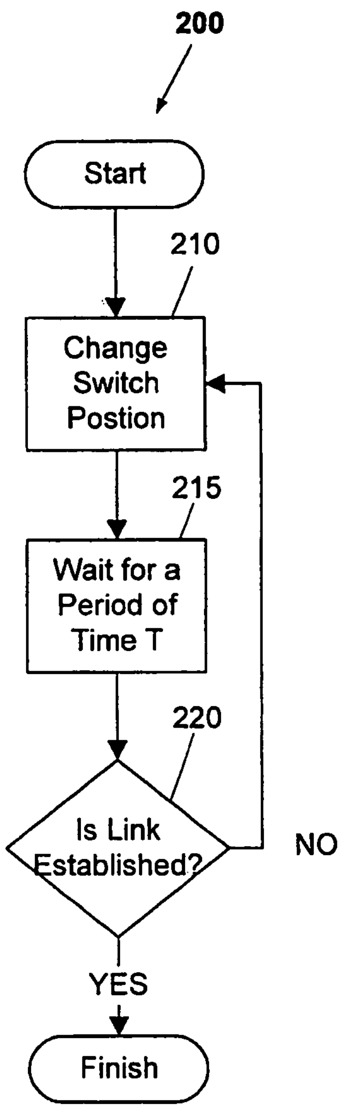

200
Start
210
Change Switch Postion
215
Wait for a Period of Time T
220
Is Link Established?
NO
YES
Finish

FIG. 4A

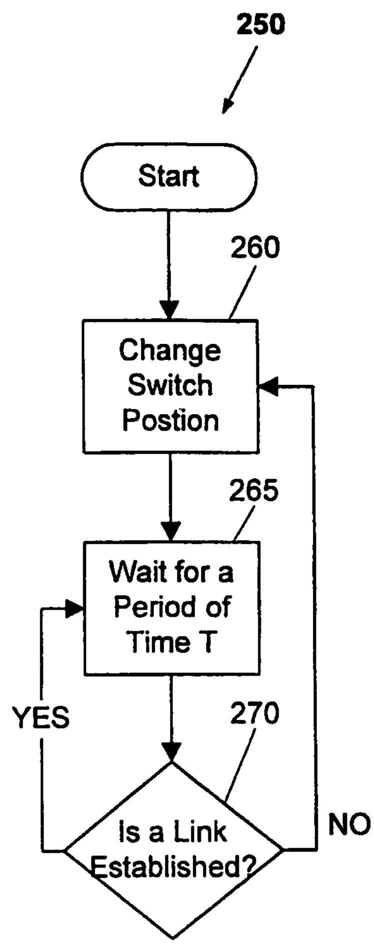

250
Start
260
Change Switch Postion
265
Wait for a Period of Time T
YES
270
Is a Link Established?
NO

FIG. 4B

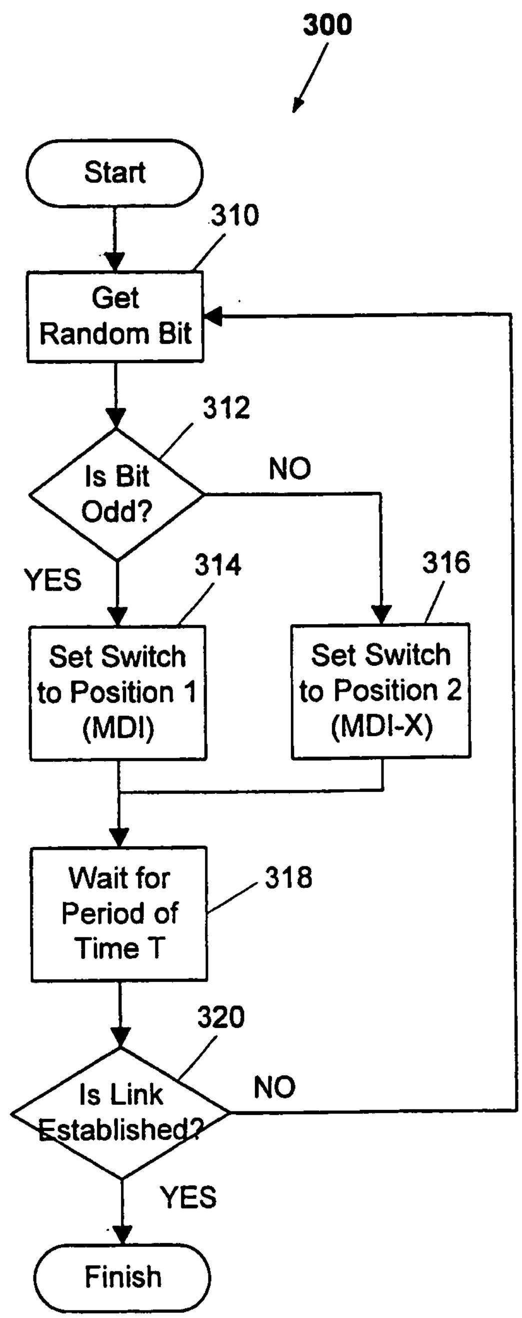

300
Start
310
Get
Random Bit
312
Is Bit
Odd?
NO
YES
314
316
Set Switch
to Position 1
(MDI)
Set Switch
to Position 2
(MDI-X)
Wait for
Period of
Time T
318
320
Is Link
Established?
NO
YES
Finish

FIG. 5

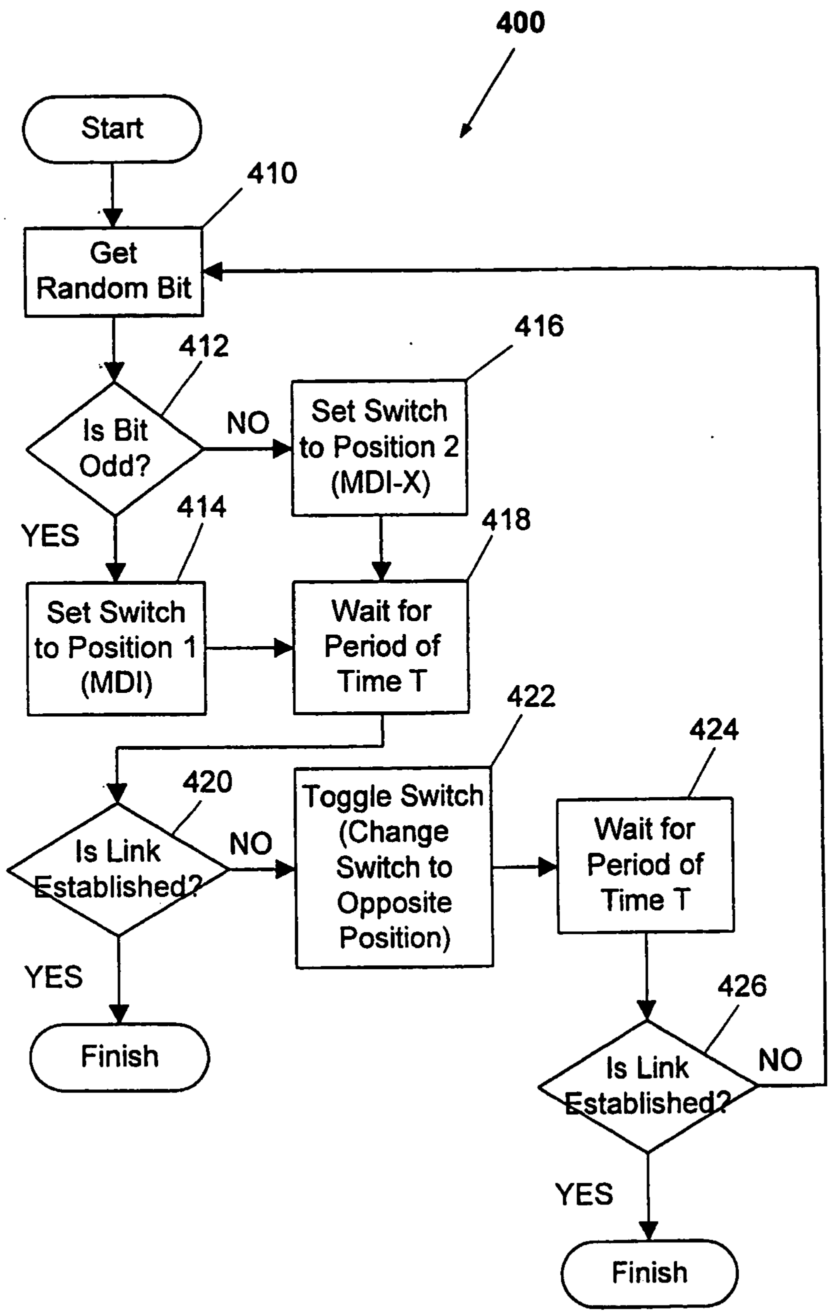

400
Start
410
Get Random Bit
412
Is Bit Odd?
NO
416
Set Switch to Position 2 (MDI-X)
YES
414
Set Switch to Position 1 (MDI)
418
Wait for Period of Time T
422
424
420
Is Link Established?
NO
Toggle Switch (Change Switch to Opposite Position)
Wait for Period of Time T
YES
Finish
426
Is Link Established?
NO
YES
Finish

FIG. 6

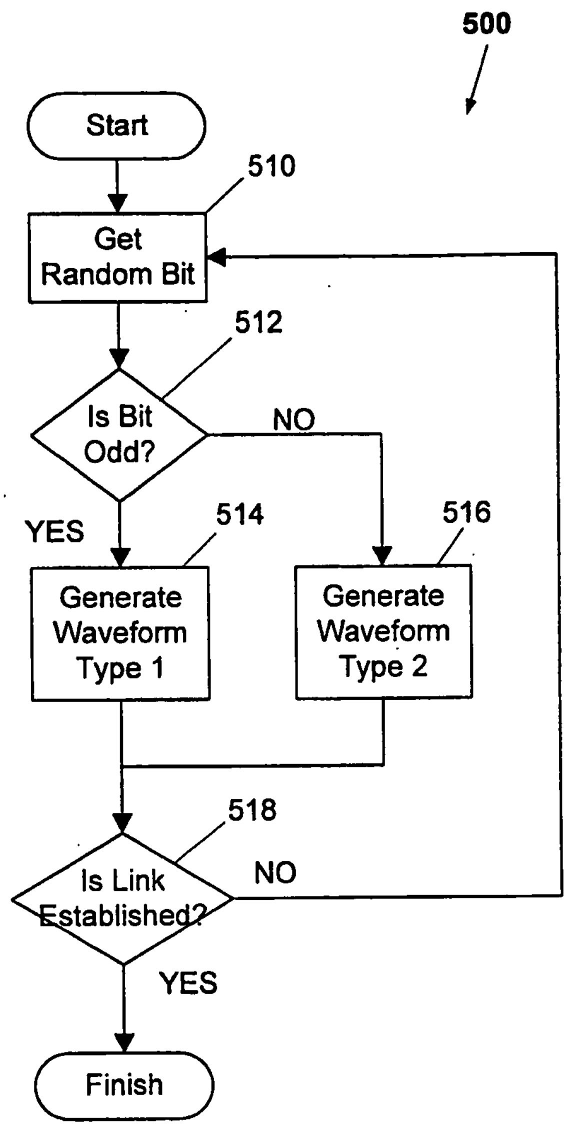

500
Start
510
Get Random Bit
512
Is Bit Odd?
NO
YES
514
516
Generate Waveform Type 1
Generate Waveform Type 2
518
Is Link Established?
NO
YES
Finish

FIG. 7

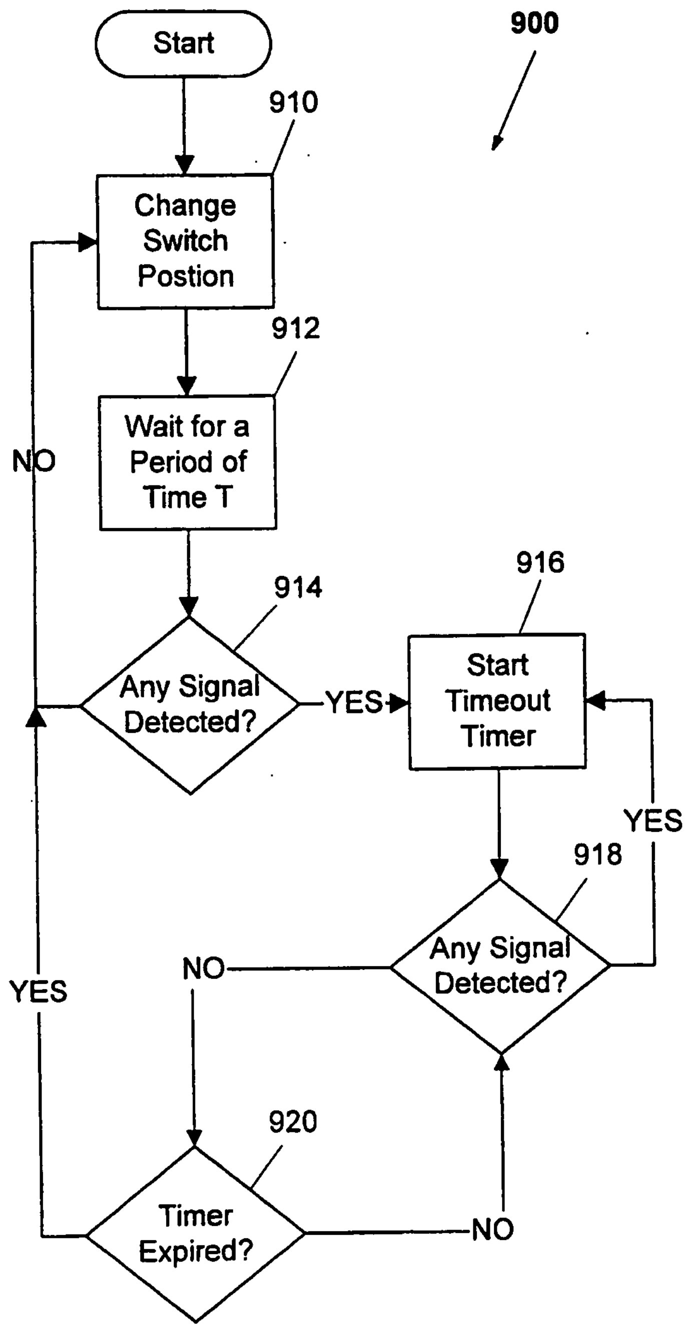
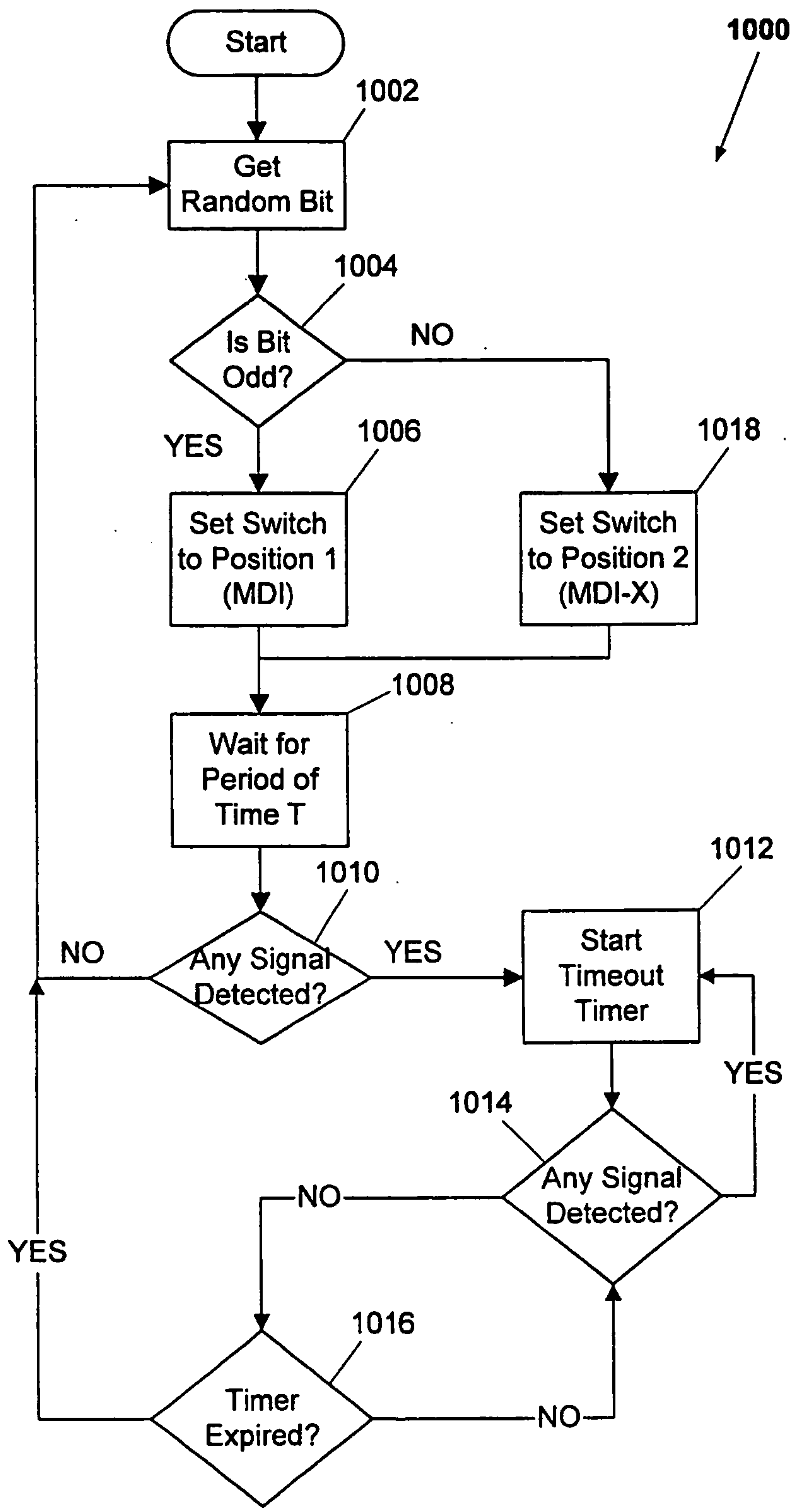

900
Start
910
Change Switch Postion
912
Wait for a Period of Time T
NO
914
Any Signal Detected?
YES
916
Start Timeout Timer
YES
918
Any Signal Detected?
NO
YES
920
Timer Expired?
NO

FIG. 9



1000
Start
1002
Get
Random Bit
1004
Is Bit
Odd?
NO
YES
1006
Set Switch
to Position 1
(MDI)
1018
Set Switch
to Position 2
(MDI-X)
1008
Wait for
Period of
Time T
1010
Any Signal
Detected?
NO
YES
1012
Start
Timeout
Timer
YES
1014
Any Signal
Detected?
NO
YES
1016
Timer
Expired?
NO

FIG. 10

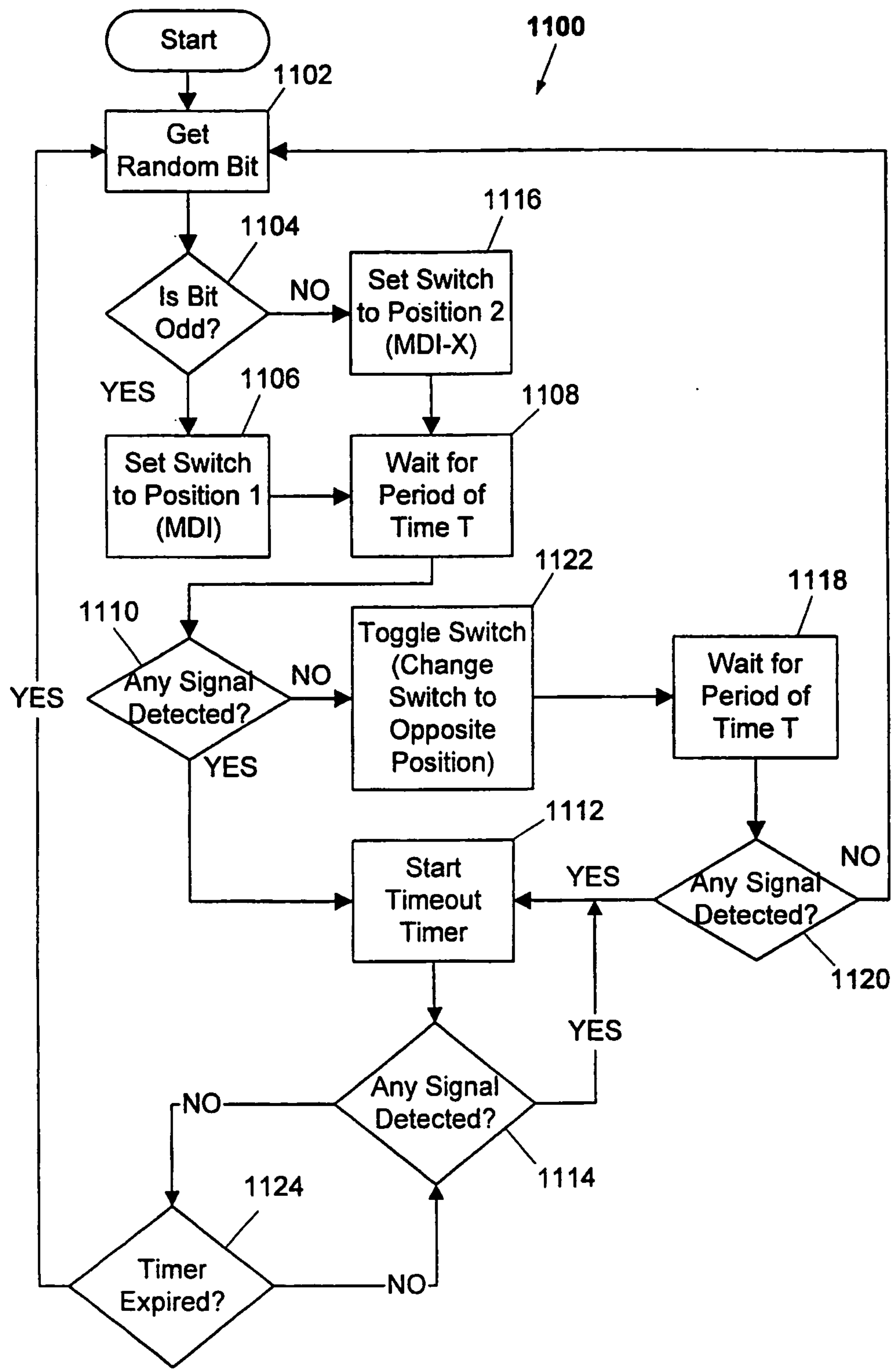

1100
Start
1102
Get Random Bit
1104
Is Bit Odd?
NO
1116
Set Switch to Position 2 (MDI-X)
YES
1106
Set Switch to Position 1 (MDI)
1108
Wait for Period of Time T
1122
Toggle Switch (Change Switch to Opposite Position)
1118
Wait for Period of Time T
1110
Any Signal Detected?
NO
YES
YES
1112
Start Timeout Timer
YES
Any Signal Detected?
NO
1120
YES
Any Signal Detected?
NO
1114
1124
Timer Expired?
NO

FIG. 11

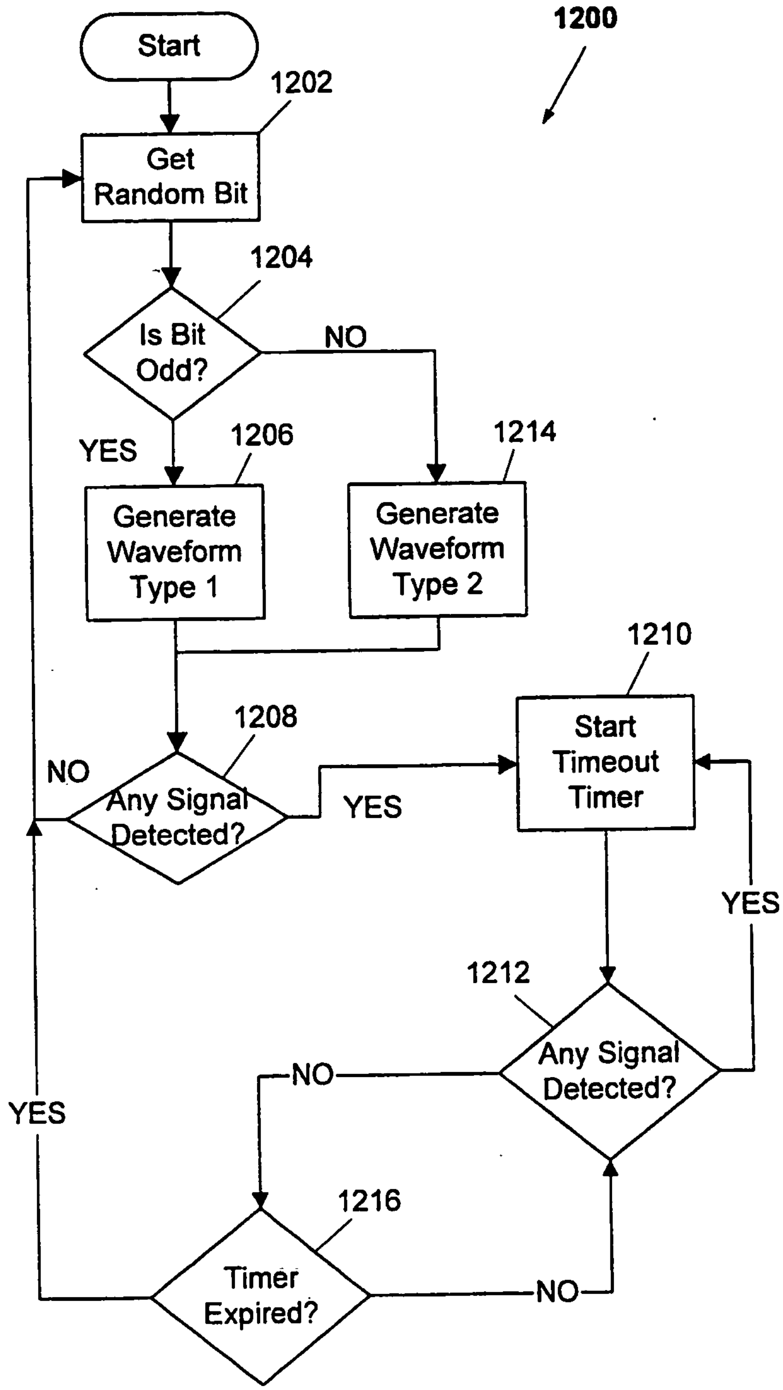

1200
Start
1202
Get Random Bit
1204
Is Bit Odd?
NO
YES
1206
Generate Waveform Type 1
1214
Generate Waveform Type 2
1210
1208
Start Timeout Timer
NO
Any Signal Detected?
YES
YES
1212
Any Signal Detected?
NO
YES
1216
Timer Expired?
NO

FIG. 12

INTERNATIONAL SEARCH REPORT	International application No. PCT/US00/06360

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :Please See Extra Sheet.
US CL : 370/282, 283, 284, 419, 420, 463, 465, 515
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/282, 283, 284, 419, 420, 463, 465, 515

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

L1= transmit$6 and receiv$8 and rj45 and switch$ and ((control adj1 logic) or control$6)
L2= L1 and (detect$6 and tim$4)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,057,829 A (VELAZQUEZ) 15 October 1991, col.1, 37 to col.2, line 8.	1-54
Y	US 4,884,269 A (DUNCANSON et al) 28 November 1989, col.2, line 5 to col.3, line 22.	1-54
Y,P	US 5,940,387 A (HUMPLEMAN) 17 August 1999, col.1, line 66 to col.2, line 26.	1-54
Y	US 5,596,575 A (YANG et al) 21 January 1997, col.2, line 33 to col.3, line 56.	1-54
Y	US 5,586,273 A (BLAIR et al) 17 December 1996, col.3, line 51 to col.4, line 30.	1-54
Y	US 5,502,391 A (SCIACERO et al) 26 March 1996, col.4, lines 8-65.	1-54

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

- * Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 MAY 2000	14 JUN 2000

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	PHUONGCHAU James R. Matthews
Facsimile No. (703) 305-3230	Telephone No. (703) 305-9509

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/06360

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest
☒ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (7):

H04B 1/10, 1/38, 1/44, 1/52, 1/58, 3/40; H04L 7/00, 12/28, 12/56, 12/66, 27/10

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

1. This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claim(s)1-42, drawn to the method/system of using random bit and time/signal to control the switch control at a network interface.

Group II, claim(s) 43-54, drawn to adaptive system in the network.

2. The inventions listed as Groups I & II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group I, claim(s)1-42, drawn to the method/system of using random bit and time/signal to control the switch control at a network interface, classified in class 370, subclass 419.

Group II, claim(s) 43-54, drawn to adaptive system in the network, classified in class 370, subclass 465.